

TRIBUTARY MONITORING IN THE WINNIPESAUKEE WATERSHED

Quality Assurance Project Plan

Lake Winnepesaukee Association

December 8, 2003

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1.0 Distribution List

The procedures and protocols identified in this Quality Assurance Project Plan (QAPP) must be followed throughout the duration of the project. The EPA approved QAPP will be distributed to the following people:

- 1) Rick DeMark, Lake Winnepesaukee Association
- 2) Pat Tarpey, Lake Winnepesaukee Association
- 3) Winnepesaukee Watershed AmeriCorps Members and/or volunteers
- 4) Lake Winnepesaukee Association Board Members
- 5) Jeff Schloss, University of New Hampshire Center for Freshwater Biology
- 6) Bob Craycraft, University of New Hampshire Center for Freshwater Biology Lab Manager
- 7) TBD, Program QA Coordinator, New Hampshire Department of Environmental Services
- 8) TBD, QA Officer, US Environmental Protection Agency (USEPA)

2.0 Project/Task Organization

Project Manager:	Pat Tarpey, Lake Winnepesaukee Association
Assistant Project Manager:	Rick DeMark, Lake Winnepesaukee Association
Project QA Officer:	Jeff Schloss, UNH Center for Freshwater Biology
Data Manager:	Pat Tarpey, Lake Winnepesaukee Association
Laboratory Manager:	Bob Craycraft, UNH Center for Freshwater Biology

The Lake Winnepesaukee Tributary Monitoring Project will involve the collaboration of a number of partners. The major partners are the Lake Winnepesaukee Association, the UNH Center for Freshwater Biology and NH Dept. of Environmental Services Volunteer River Assessment Program (VRAP). Pat Tarpey, Lake Winnepesaukee Association is the Project Manager and is responsible for coordinating the project with UNH, development of sampling design, recruitment and coordination of training of volunteers, and coordination of the sampling teams and transport of the samples to the lab.

Bob Craycraft is the laboratory manager for The UNH Center for Freshwater Biology, and will be responsible for sample processing, and analytical measurements. Pat Tarpey is the Data Manager and will be responsible for data entry, development of the project database and monthly summaries of quality control data.

UNH field personnel will be responsible for conducting stream flow measurements.

NH DES VRAP will be responsible for training the volunteers in the standard operating procedures for collecting water samples.

Sampling will be conducted by members of the Winnepesaukee Watershed Corps, the Lake Winnepesaukee Association, and volunteers from the watershed community.

Jeff Schloss and Bob Craycraft of UNH will prepare the final report. The data will be used to evaluate relative risks to Lake Winnepesaukee from tributaries feeding to the lake. The report will summarize risks and make recommendations for targeting areas for further monitoring, planning and/or remedial action. The final report will be submitted to each Conservation Commission, Planning Board, and Conservation District in the Winnepesaukee watershed, and NH DES.

The NHDES Program QA Coordinator in the Watershed Assistance Section (currently vacant), is responsible for coordination with the USEPA Project Manager.

The primary users of the data will be the Lake Winnepesaukee Association, UNH Center for Freshwater Biology, Planning Boards and Conservation Commissions of municipalities within the Winnepesaukee Watershed, Belknap and Carroll County Conservation Districts, and NHDES.

3.0 Problem Identification/Background

The total area of the Lake Winnepesaukee watershed is 236,225 acres and is made up of sixteen communities, with eight of the sixteen owning waterfront acreage. Lake Winnepesaukee is the largest freshwater body in New Hampshire comprising 44,586 acres of surface water. Other lakes, ponds, rivers, and streams cover 11,099 acres contributing considerable volumes of water to the lake. The water quality of these streams can be significantly impacted by the land use and development activities occurring in the watershed, but to date, there has been only limited sampling of their water quality.

The area is continuing to grow. The local and state economy thrives on the tourism and the increase in summer population experienced in the lakes region puts more strain on the region's natural and recreational resources. There is a tremendous challenge in developing a management plan that will address water quality issues on a watershed-wide basis when dealing with such a large watershed with a vast and diverse stakeholder community. Before such a plan can be developed, a better understanding of the past and current lake conditions as well as critical determinants that impact the water quality needs to occur. While we currently have obtained a great deal of data on in-lake conditions from UNH's Lakes Lay Monitoring Program, we need to get a much better handle on what part the contributing waters from tributary lakes and streams play in impacting the lake water quality. As a first step in this process, the Lake Winnepesaukee Association proposes to implement a pilot tributary monitoring program at the outlet of nine of the major tributaries to the lake. The data obtained will provide a current assessment or characterization of the water quality of the monitored streams. The assessment will help identify areas that may require further monitoring, remedial or planning efforts, and will be used to measure the success of these efforts.

The watershed organization plans to use the results obtained to educate local residents on the connections between land use and water quality. A future goal of the project will be to establish a long term monitoring program of the tributaries that will continue to provide data that can be used to measure the success of future watershed management efforts.

4.0 Project/Task Description

The Lake Winnepesaukee Association (LWA) in conjunction with UNH and NHDES will monitor the water quality and stream flows of selected tributaries feeding Lake Winnepesaukee under baseflow, high and low flow conditions, from March 2004 through October 2005. In addition sampling will occur during several storm events to capture runoff from these events. The project will be completed by June 30, 2006, as that is the date the grant contract with NHDES expires.

Volunteer recruitment will be conducted by LWA during the fall and winter of 2003, with training held in spring of 2004 prior to the first sampling.

Nine tributaries will be monitored for total phosphorus, nitrates, E. coli, turbidity, conductivity, pH, temperature, dissolved oxygen, and stream flow. Phosphorus is the most important nutrient to sample for as it is considered the limiting nutrient for lakes and a primary source of phosphorus comes from human related activities in the watershed. Nitrates are of secondary importance, but since they are transported more quickly in runoff, they can be used to identify possible septic system failures or fertilizer runoff. As one of the main purposes of the project is to establish a characterization of the water quality of the tributaries feeding the lake, each of the parameters is an important component of the study.

The object of the sampling strategy is to obtain base flow, high and low flow conditions, and runoff from storm events. To accomplish this, sampling will begin in March or April 2004 to capture runoff from spring melt. Each tributary will be sampled monthly beginning with the March/April 2004 sampling. During the months of July, August, and September, biweekly sampling will be conducted as summer represents a period of increased human related activity in the watershed. A final sampling for the season will be conducted in October 2004. Sampling will begin again in March or April 2005 to collect additional samples during spring melt conditions when a lot of erosion and nutrient loading occurs.

To put the water quality results in perspective in terms of actual loadings, stream flow measurements will be collected during various base, low, and high flow conditions. Utilizing staff gages, stream depth will be measured for each tributary during each sampling event. The staff gauge heights will be used to calculate the ambient discharge during each sampling event.

All water samples will be analyzed for total phosphorus, nitrates, pH, specific conductivity, turbidity, dissolved oxygen, and temperature. In addition, during the months of June, July, August, and September, water samples will also be analyzed for E. coli.

Storm Events

In addition to the regular sampling schedule, samples from three storm events (one spring, one summer, one fall) will be collected over the two season sampling period to assess the runoff impacts from land use and development activities.

Due to the logistical difficulty in coordinating volunteers to sample nine tributaries at short notice and within a relatively short period of time, volunteers will attempt to sample as many tributaries as possible during a storm/rain event. Visual surveys and digital photographs will be used to assess and document storm impacts on those tributaries where ambient water quality data are not collected.

Project Schedule

The project will proceed as outlined in the following Table:

Table 1. Project Tasks

Task	Time Schedule to complete	Who	Rationale and desired result
Development and approval of QAPP – includes the study design: tributary and parameters selection, Monitoring frequency, methods and SOPs	April to November 2003	LWA Team Leader in conjunction with UNH Center for Freshwater Biology and NHDES	EPA approved Quality Assurance Project Plan that will help ensure the data collected meet QA/QC standards
Recruitment and training of volunteer monitors	September – December 2003	LWA with assistance from UNH and NHDES	Trained Sampling monitors for quality assurance and control
Tributary sampling and analysis	March/April 2004 through Sept. 2005	Volunteer monitors – sampling and field analyses UNH - lab analyses	Collection of tributary impact data. Emphasis placed on base flow, spring melt, high and low flow conditions
Data processing & monthly summaries	April 2004 – Oct. 2005	UNH and LWA	Regular management and review of data
Annual review of QAPP	December 2004	LWA	Assurance that data quality objectives are being met and data collected meet QA/QC standards
Data analysis, interpretation, and final report	Oct. 2005 – January 2006	UNH	Documentation of water quality necessary to direct future watershed planning and management efforts. Will identify areas with greatest need.
Outreach to communities	Summer 2006	LWA, UNH	Presentations of results to local municipalities, homeowner associations, camps, developers Results posted on LWA website

5.0 Data Quality Objectives for Measurement Data

Establishing data quality objectives (DQO's) prior to sampling ensures that the quality of the data collected can be determined. This includes evaluating water chemistry data to assess analytical laboratory results (e.g., accuracy, precision, and comparability) and potential problems of contamination during the collection of water samples. Table 2 contains the analytical objectives for each parameter.

Table 2. Data Quality Objectives in a water matrix

Parameters	Desired Precision	Accuracy	Measurement Range
Field Measured Parameters (based on NHDES VRAP)			
Conductivity	RPD ≤ 5%	± 25.0 µS/cm	0 – 4999.9 µS/cm
pH	RPD ≤ 0.2 std units	± 0.2 pH units	0 – 14 pH Units
Temperature	RPD ≤ 5%	*	-5° to 45°C
Turbidity	RPD ≤ 5%	± 1.0 NTU	0 – 1100 NTU
DO	RPD ≤ 5%	± 2% of saturation	0 to 500% air saturation or 1 to 50 mg/L
Stream Flow	RPD ≤ 10%	90%	
Laboratory Measured Parameters (UNH Center for Freshwater Biology)			
Total Phosphorus	RPD ≤ 15% (Field) RPD ≤ 10% (Lab)	90-110%	5 – 200 ug/L
Nitrate/nitrite	RPD ≤ 15% (Field) RPD ≤ 15% (Lab)	85-115%	30 – 200 ug/L
E. coli	RPD ≤ 50%	NA	0 - TNTC

* According to the NHDES VRAP QAPP, Temperature sensors do not require accuracy determinations, as the sensors are tested in the laboratory prior to the commencement of the monitoring period.

Precision

Precision is the degree of agreement among repeated measurements of the same characteristic on the same sample or on separate samples collected at the same time and location. Precision will be assessed as the relative percent difference between replicate measurements taken in the field, and the relative percent difference between duplicate samples collected. Replicate measurements will be taken for each field parameter measured.

The number of people sampling will determine how many duplicate samples are collected during each sampling event. If multiple teams of volunteers collect samples during a field visit, then each team will collect at least one duplicate sample for lab analysis. If different volunteers each sample a different site, then a duplicate sample will be collected for each site. Analyzing sample lab duplicates and determining the relative percent difference of the lab duplicates and the field replicates will measure precision.

The relative percent difference (RPD) will be calculated as follows:

$$RPD = \left(\frac{|x_1 - x_2|}{\frac{x_1 + x_2}{2}} \right) \times 100$$

where x_1 = the larger of the two values and x_2 = the smaller of the two values. RPD will be calculated for each sampling visit. The desired field and lab precision data are reported in Table 2. If the relative percent difference (RPD) falls outside of the desired precision, the sample will be run again to determine if there was an error in the analyzer or the equipment that led to the imprecision.

Accuracy

As an indicator of measurement confidence, percent accuracy will be calculated based on analytical results of spiked samples of known chemical concentrations of total phosphorus and nitrates. A sample will be divided into two portions (aliquots). A known amount of standard is added (spiked) to one of the aliquots. Both aliquots are then analyzed and the amount of the spiked material recovered is compared to the amount added using the following equation:

$$\% \text{ Accuracy} = \frac{\text{SpikedSampleConc} - \text{UnspikedSampleConc}}{\text{Spiked Conc. Added}} \times 100$$

Spiked TP and nitrate samples will be analyzed at a frequency of 5% or one per analytical batch, whichever is more frequent.

For pH, accuracy is expressed as the difference between the mean measured value and the theoretical value.

Representativeness

The primary goal of this study is to obtain a current characterization of the water quality of the major tributaries feeding Lake Winnepesaukee at their outlets. Since water quality monitoring of the tributaries has not been done before, it is unknown whether the data will actually depict the true environmental conditions as no data exists to compare it to. However, tributaries were selected to represent the various land uses occurring in the surrounding watershed, and from all areas of the lake. Although the water quality of the stream at the outlet may not represent the water quality upstream, it does represent the quality of the water entering the lake, which is the focus of this study. The sampling plan includes regular monthly sampling as well as storm event sampling, therefore we will be collecting samples that include a range of flow conditions, which hopefully will be representative of the varying conditions in the tributaries. The results of the study will be used to determine sites that may require further monitoring upstream.

Comparability

Maintaining consistency with SOPs, sampling locations, and sampling methods will achieve comparability among samples. Samples will be collected at the same, specified locations throughout the study and all samples will be processed within the specified holding times. Many of the sampling locations are near existing Lakes Lay Monitoring Program (LLMP) active monitoring sites, so the data will be compared to the data being obtained from the lake sampling. UNH Center for Freshwater Biology lab is performing the current analyses of the lake sampling sites, and they will also be doing the analyses from the tributary sampling sites.

The data should be consistent with other VRAP studies as we are using their equipment and established protocols.

Comparability is important as it is hoped that the data obtained can be used as an indication of what may be occurring in other streams with similar subwatershed land uses and topography.

Completeness

The completeness of the database is a critical aspect of data quality and data usefulness. Since phosphorus is the parameter of primary importance in this study, and an indicator of human related activities occurring in the watershed, it is important to obtain as much data as possible from spring melt, storm events, and baseflow. Due to the logistical difficulty in obtaining water samples during storm events from all sites within a given time period, and the uncertainty of predicting weather conditions, it is expected that there will be incomplete data for some storm events. However, visual surveys and digital photos will be taken for those streams that volunteers are unable to sample during storm events.

The goal is to have obtained 100% of the planned samples; however, 90% completeness will be considered acceptable.

6.0 Training Requirements/Certification

All volunteers participating in the Winnepesaukee Tributary Monitoring project will be trained in all aspects of collecting water quality samples. Volunteers will attend a training session conducted by the NH Department of Environmental Services Volunteer River Assessment Program (VRAP) personnel on calibration and use of equipment and correct water sample collection protocols for physical and chemical analyses. Training will be conducted prior to the first sampling visit and will be repeated prior to the next sampling season. A record will be kept for each volunteer that documents the date training was received, the protocols trained in, and that a proficient level of ability was demonstrated. This training record will also document any further training that the volunteer may receive and the midseason evaluation conducted by the project manager.

Volunteer sampling teams will be accompanied and performance evaluated by either the Project Manager or Project QA Officer midseason. Whenever possible, any required adjustments in sampling technique will occur on-site during the evaluation.

Water Quality personnel from UNH Center for Freshwater Biology will be collecting the stream flow measurements using a SonTek Flowtracker Acoustic Doppler Velocimeter.

Trial runs will be conducted prior to start of the monitoring project to assess the volunteers' comfort level and competency in conducting the physical and chemical analyses.

7.0 Documentation and Records

Documentation includes training logs, field data sheets, sampling station identification forms, visual survey forms, photographs, laboratory notebooks that include information regarding calibration, quality control checks on volunteer procedures and record keeping, and measurement of pH, temperature, dissolved oxygen, turbidity, conductivity, stream flow and the UNH CFB laboratory measurement of total phosphorus, nitrates, and E. coli.

Separate data forms are used for stream sampling and stream flow measurement data. Copies of each field data form are included in Appendix A.

Each sampling team will complete field data forms on-site at the time of sampling or when measurements are made. The name of each member of the sampling team is recorded on each data form.

Due to logistics it may not be possible for the volunteers to sample all sites during the first flush of a rain event. In those instances where a tributary is not sampled during the rain event, the watershed survey visual assessment forms will be used.

At the completion of sampling, one volunteer will act as courier and will deliver all of the water samples and data forms to the Laboratory Manager at the UNH Center for Freshwater Biology. Water samples will be delivered to UNH within 6 hrs of collection in order to comply with the maximum holding time requirement for bacteria. The Laboratory Manager will review each data form and contact the project manager within 72 hours if unresolvable problems are found. The Laboratory Manager will photocopy all completed data forms and coordinate delivery of the originals to the Data Manager. The photocopies will be archived until the completion of the project.

The laboratory notebooks of analytical measurements made at UNH CFB will be photocopied monthly and sent to the data manager. The laboratory notebooks will be kept at the UNH Center for Freshwater Biology lab.

8.0 Sampling Process Design

The purpose of the project is to establish a characterization of the water quality entering Lake Winnepesaukee from the major tributaries in its watershed. This is a necessary first step to assess nutrient loading and potential threats within the Lake Winnepesaukee watershed. Nine tributaries have been selected to be monitored beginning in the spring of 2004 and continuing through June 2005.

Selection of the tributaries has been based on:

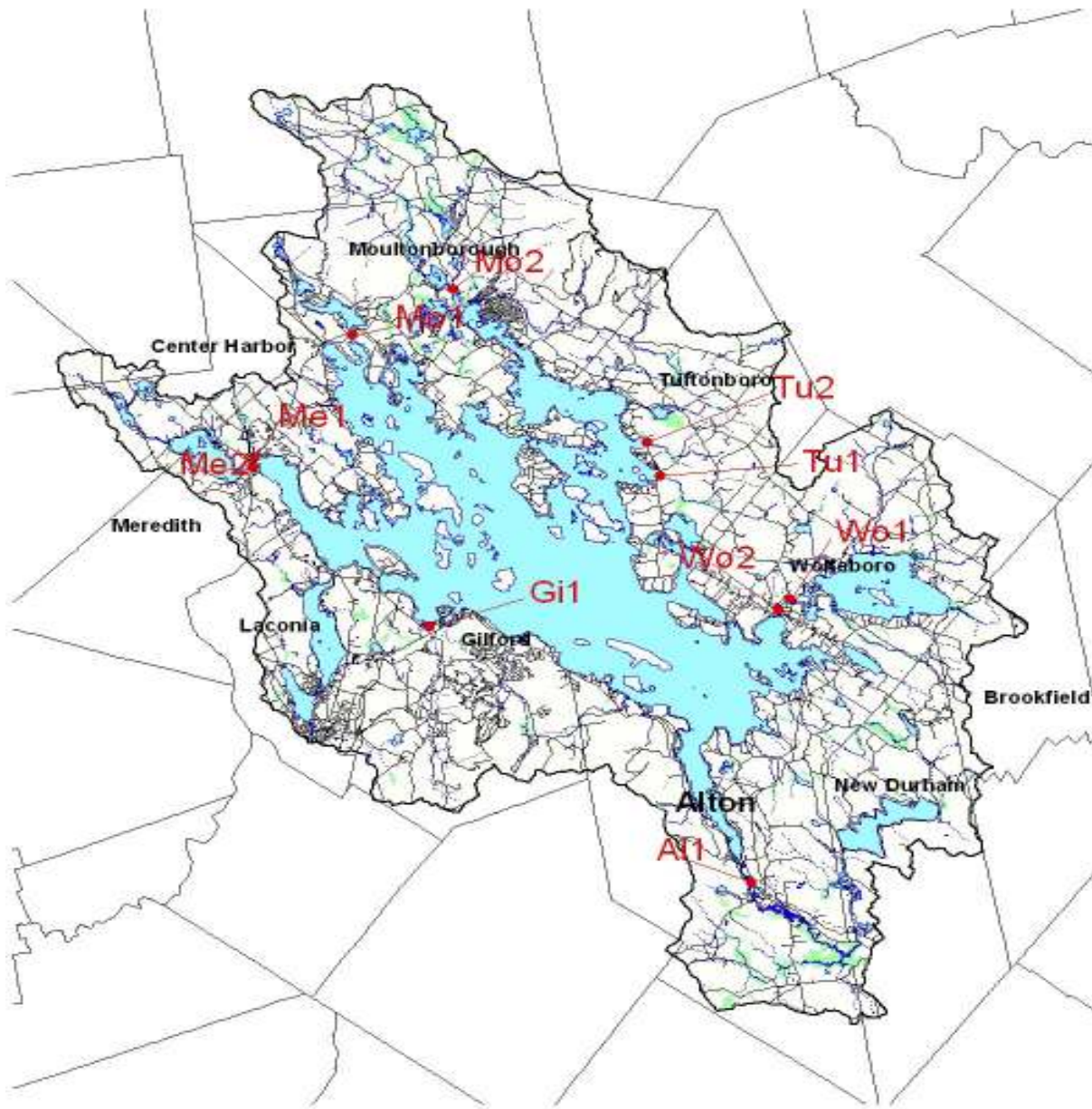
- Representation from each area of watershed
- Easy access for volunteers
- Represent various development patterns/land uses in subwatershed area
- Contribute fairly large volume of output to lake
- Feed near existing LLMP sites

Stream identification codes, locations, and rationale are summarized in Table 3.

Table 3. Stream Sites and Rationale

<u>Site</u>	<u>Name/Location</u>	<u>Directions</u>	<u>Rationale</u>	<u>Access</u>
Mo1	Outlet from Lake Kanasatka	Rte. 25, Moultonboro	Large volume of output empties into narrow cove. – Sparse residential development	Public
Mo2	Half Way Brook Moultonboro	Lee's Mills Rd., Moultonboro	Relatively undeveloped area; however Conservation Commission advised 22 homes going in upstream on Ossipee Mtn. Road (Old Davis Farm) – sediment problems	Public
Tu1	Nineteenmile Brook Tuftonboro	Rte. 109, Tuftonboro	Large stream, many private wells contaminated near – public beach at outlet	Public

Tu2	Twentymile Brook Tuftonboro	Rte. 109, Tuftonboro	Similar geologic area to above – conservation easements – public beach at outlet	Public
Wo1	Outlet from Crescent Lake/Wolfeboro	Rte. 28, Wolfeboro	Outlet for Crescent Lake and Lake Wentworth, empties in Back Bay in Wolfeboro	Public
Wo2	Smith River/Wolfeboro	Rte. 109, Wolfeboro	Outlet from Back Bay, relatively stagnant flow – lots of developed area/impervious surfaces surrounding (downtown Wolfeboro)	Public
Al1	Merrymeeting River/Alton	Off Rte. 11, Alton	Large volume of water into narrow bay. Travels through large wetland areas before emptying into lake, new residential development projects and reopening of gravel pit	Public
Gi1	Gunstock Brook/Gilford	Rte. 11B, Gilford	A lot of erosion problems/downstream flooding. Recent streambank restoration done downstream – monitor effectiveness of measures, travels through residential areas	Public
Me1	Hawkins Brook/Meredith	Rte. 25/3, Meredith	Traverses wetlands, sandpit, junkyard, school, and impervious surfaces. New housing development on Rt. 25	Public
Me2	Mills Falls/Meredith	Rte. 25, Meredith	Overflow from Waukegan, large volume of water. Highly developed area, lots of impervious surface	Public



Winnepesaukee Tributary Monitoring Sites

Figure 1. Winnepesaukee Tributary Monitoring Sites

Winnepesaukee Tributary Monitoring Sites



Winnepesaukee Tributary Monitoring Sites



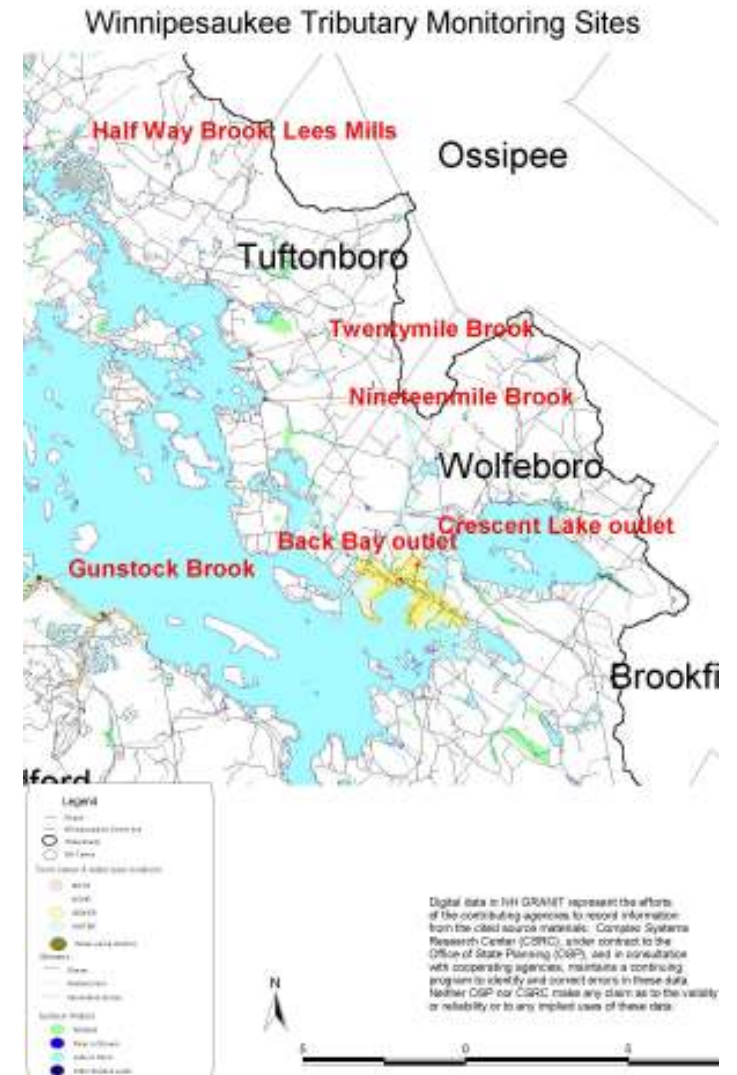
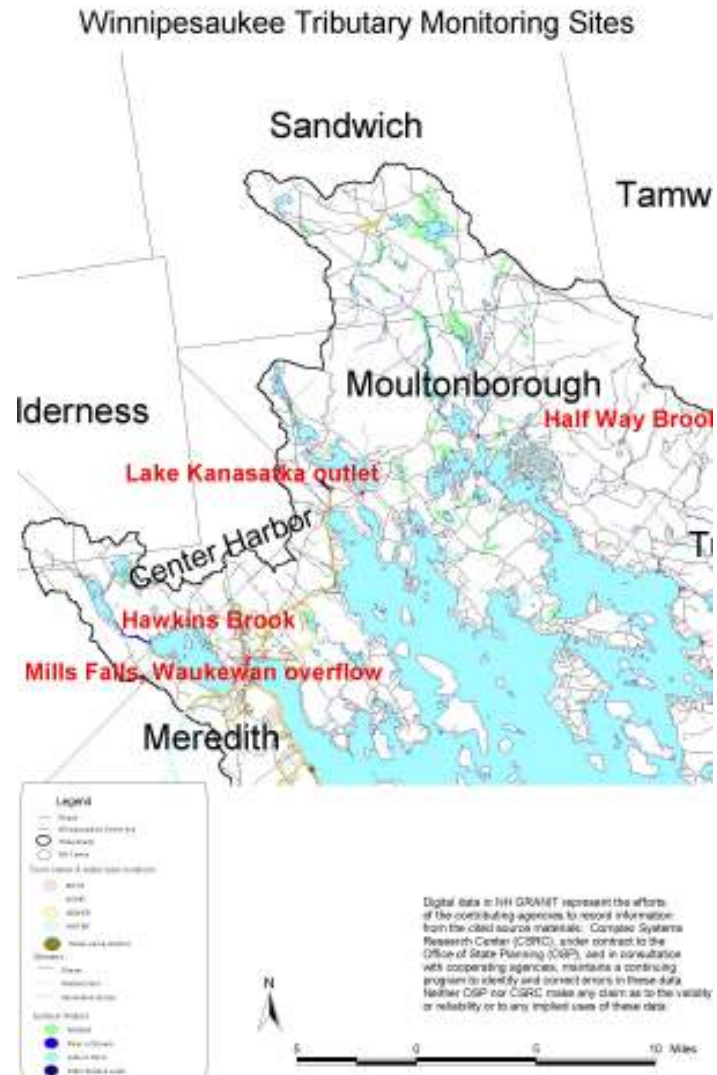


Figure 1a: Winnepesaukee Tributary Monitoring Sites

The Winnepesaukee Tributary monitoring sites will be monitored for total phosphorus, nitrates, E. coli, turbidity, conductivity, pH, temperature, dissolved oxygen, stream depth and flow. Table 4 lists the parameters and rationale for each.

Volunteers from the Lake Winnepesaukee Association, Winnepesaukee Watershed Corps, and community members will collect water quality samples. All participating volunteers will be required to undergo training in sampling and handling procedures.

Each of the nine tributaries will have water samples collected and measurements taken on a minimum of sixteen sampling dates; three of which will be storm events.

TABLE 4. Sampling Parameters and Rationale

Sampling Parameters	Rationale
Total Phosphorus	Limiting nutrient of lakes. Sources arise primarily from human related activities – erosion from land disturbance(development), fertilizers
Bacteria -E coli	Many public beaches at outlets of tributaries; cottage developments with old septic systems are common in the watershed
Nitrates	Quickly transported in runoff as they have less soil affinity than phosphorus. Sometimes better indicator of faulty septic system in dry weather, fertilizer runoff
Conductivity	Simple water quality measurement that indicates changes in dissolved solids, salts which can include metals, sewage and road salts
pH	To determine if the growth and reproduction of aquatic organisms is a problem.
Dissolved Oxygen	Critical to stream organisms. Low DO can result when stream burdened with sediment, organic wastes
Turbidity	Optical Indicator of sediment, dissolved solids and soil erosion problems
Temperature	Indicator of health of the stream. Critical to stream organisms.
Stream Flow	To put water quality results in perspective in terms of actual loadings

Dry Weather Monitoring

The object of the sampling strategy is to obtain base flow, high and low flow conditions. To accomplish this, monthly sampling will be conducted from March through June 2004. The March/April sampling will be timed to try and capture runoff from snowmelt in the spring, and a monthly sampling in May and June will capture high flow conditions in the spring. Beginning in July, biweekly sampling will be conducted through September. This will assist in collecting more data to assess for base flow, low flow, and possible impacts from increased human activity during the summer months in the watershed. A final monthly sampling will be conducted in October 2004. Sampling will be conducted again the following March/April 2005, and monthly samples will be collected in May and possibly June.

Staff gages will be installed at each tributary by UNH personnel in order for volunteer monitors to record stream depth during each sampling event to assess for different flow conditions throughout the season. Stream flow measurements will be collected by UNH field personnel using a SonTek Flowtracker Acoustic Doppler Velocimeter. Stream flow measurements will only be collected under varying flow conditions such as spring melt, base flow, low and high flow conditions.

Three sampling teams of 2 - 3 people will be used for each sampling event. Each team will have three tributaries assigned to it to sample. QC samples (blanks and field duplicates) will be distributed among sampling teams and stations so that each will receive adequate QC coverage.

During dry weather sampling, two water samples will be collected from each tributary site. The first will be analyzed for total phosphorus; the second for nitrates. During the months of June, July, August, and September, a third sample will be collected monthly and analyzed for E. coli. This period represents increased use of summer residences and rental cottages. Due to the number and age of most of these residences and cottages, the possibility of failing septic systems, leaking pipes, and overflows is high. Many of the tributaries being monitored outlet at or near public beaches.

Wet Weather Monitoring

Storm samples will be collected during a minimum of three rain events (one during spring, one summer, and one fall) over the project period. This will allow for some flexibility in case of an unusually dry season. We will attempt to sample all of the tributaries during a rain event; however, due to the large size of the Winnepesaukee watershed, it may be raining on the east side of the lake and not the west, or vice versa. If it is logistically impossible to sample all sites on the same day during a rain event, visual surveys will be conducted and the information recorded on the watershed survey forms, including digital photographs taken on those streams not sampled.

Storm sampling will be limited to precipitation events during which the rainfall totals a minimum of 0.3 inch over a 24 hour period, and will be preceded by a minimum 72 hr. dry period. The term "dry period" will be defined as less than 0.1 inches of rainfall.

The project manager will notify the volunteers 24 hrs prior to a forecasted rain event, and assemble the team(s) available for sampling. The project manager will coordinate the delivery of sampling equipment, timing of the sampling, and transportation of samples to the lab. Samples will be collected within the first hour of rainfall. A minimum of two people will be required to sample each site. A total of 16 volunteers would be ideal in order to sample all sites during a rain event.

During wet weather sampling, three water samples will be collected from each site. The first will be analyzed for total phosphorus, the second for nitrates, and the third for E. coli. Flow measurements will not be made during storm events as it is exceedingly difficult and time consuming to collect discharge measurements during each storm event. Alternatively, we will rely on the staff gauge heights which can be used to calculate discharge.

9.0 Sampling Method Requirements

The standard operating procedures for field sampling are provided in Appendix B. The Project Manager will review procedures with the volunteers at the beginning and midway through the project study, and make any corrective actions deemed necessary. The requirements for the type of container used to collect water samples are based on the chemical analysis conducted, and the use

of preservative (Table 5). Clean washed sampling bottles are picked up from the UNH lab prior to the sampling event.

Table 5. Sampling Method Requirements

Parameter	Sample Matrix/ Collection Method	Sample Volume	Sample Holding Container	Preservative	Maximum Holding Time
DO	YSI Model 95	n/a	n/a (<i>in situ</i>)	none	immediately
pH	Orion Model 210A pH meter	n/a	n/a (<i>in situ</i>)	none	immediately
Stream Flow	SonTek Flowtracker ADV	n/a	n/a (<i>in situ</i>)	none	immediately
Conductivity	YSI Model 30/30M	n/a	n/a (<i>in situ</i>)	none	immediately
Turbidity	Lamotte Model 2020	n/a	n/a (<i>in situ</i>)	none	immediately
Temperature	YSI Model 95	n/a	n/a (<i>in situ</i>)	none	immediately
Total Phosphorus	Water/Grab	2 L	PP	None – will be preserved at the lab upon delivery	Delivered same day – once preserved; 28 days
Nitrates	Water/Grab	2 L	PP	None – will be preserved at the lab upon delivery	Delivered same day – once preserved; 28 days
E. coli	Water/Grab	250 ml	Sterile polyethylene	4°C on ice	6 hours in field 2 hrs in lab

10.0 Sample Handling and Custody Requirements

All sample bottles will be labeled in the field (Figure 2). Water samples will be iced immediately after collection and transported to the UNH Center for Freshwater Biology lab. The UNH Lab will pull the nitrate and total phosphorus samples from the 2L bottles. The nitrate and phosphorus samples will be poured into the appropriate bottles in the lab and preserved/refrigerated accordingly. The measurement of E. coli will be conducted within 2 hours of arrival at the lab.

A sampling logbook will be maintained by the Laboratory Manager documenting the custody of the water samples from the field to the analytical laboratory and will include the following:

1. Sample station number, sample identification and location,
2. Date and time the sample was collected,
3. Sample type: Grab,
4. Sample matrix: Water,
5. Number of containers turned into the lab,
6. Preservative used in each container,
7. The analysis requested,
8. Sampler name and signature, and
9. Date and time the samples were dropped off at the lab.

The chain of custody for water samples is as follows: In the field, samples are the responsibility of, and stay with the sampling team. Once all of the samples have been collected they will be transported to the UNH Center for Freshwater Biology Laboratory for analysis and temporary storage by one courier. The laboratory manager will record date and time of arrival and refrigerate the samples that will be analyzed for total phosphorus and nitrates. The E. coli analysis will be

conducted within two hours of arrival at the lab. Water samples will be collected in the morning so that they arrive at the lab prior to 2 p.m. in order to conduct the E. coli test.

Winnepesaukee Tributary Monitoring Project	
Date ____/____/____	Collection Time _____
Site Name _____	Site Code _____
Sample number ____ of ____	Preservation: Y / N
Test (s) Requested _____	
Sampling Team _____	

Figure 2. Sample Label

11.0 Analytical Methods Requirements

The analytical measurements that will be made are all based on existing standard methods (Table 6). The standard operating procedures (SOP) for pH, temperature, turbidity, conductivity, dissolved oxygen measurements to be made in the field are included in Appendix B. The SOPs for total phosphorus, nitrates, and E. coli measurements to be made at the UNH Laboratory are included in Appendix C. Bob Craycraft, lab manager at UNH Center for Freshwater Biology, will be responsible for making any corrective actions deemed necessary to analytical methods.

Table 6. Analytical Methods

Analyte	Matrix	Analytical Method (see Appendix B & C for SOPs)
Field Measurements		
Conductivity	Water	YSI Model 30
Turbidity	Water	Lamotte Model 2020
Dissolved Oxygen	Water	YSI Model 95
pH	Water	Orion Model 210A Meter
Temperature	Water	YSI Model 95
UNH Lab		
Total Phosphorus	Water	Standard Methods 4500-P.E.
Nitrates	Water	UNH CFB Lab – Nitrate Nitrogen SOP (2003)
E. coli	Water	AWWA, 1998 Standard methods for the Examination of Water and Wastewater, 20 th ed.

12.0 Quality Control Requirements

Several types of quality control samples will be used to quantify data quality (Table 7). These include samples collected in the field and aliquotted in the laboratory (Table 8).

Table 7. Quality Control Samples

Quality Control Sample Type	Definition
Field Blank	A sample of deionized water that does not contain the measured analytes. The field blank is taken into the field and transferred into sample bottles in the same manner as routine samples. The field blank facilitates evaluating entire measurement process from sample collection through lab analysis.
Laboratory Blank	A sample of distilled or deionized water that does not contain measured analytes. The laboratory blank is used to check the cleanliness of the analytical process.
Replicate Samples	A second measurement made with a field instrument of the same sample of water. A replicate measurement will be taken for each field measured parameter.
Duplicate Samples	A second sample collected at a field site. The duplicate sample is processed and analyzed in the identical manner as routine samples.
Spiked Samples	A sample that contains a known concentration of the analyte(s) of interest has been added (sometimes called "audit samples").

The expected sample loads associated with sampling are shown in Table 9. A field duplicate will be collected on every sampling event, which will result in at least a minimum of 16 duplicates collected throughout the study. This represents ~8.3% of the total collected sample load.

One field blank will be collected on each sampling event. In total there will be 16 field blanks generated or ~8.3% of the total collected sample load.

Overall, 32 or 16.7% of the collected sample load will be QC samples. Additional QC samples will include lab blanks, lab duplicates, and spiked samples.

One laboratory blank will be analyzed at both the beginning and end of each batch of samples analyzed at the CFB laboratory. Laboratory duplicates will compose 100% of the Nitrate and the Total Phosphorus samples analyzed while 10% of the E coli samples will be replicated. Five percent (5%) or one per analytical batch (whichever is more frequent) of the nitrate and the total phosphorus samples will be spiked to determine the accuracy of the respective procedures.

Results of laboratory and field assessments based on QC samples (blanks, duplicates, replicates, and spiked samples) will be summarized monthly starting with March/April 2004. If these results indicate a sampling or an analytical problem the data will be either thrown out or qualified. If the problem is associated with sampling technique then the sampling protocol will be reviewed with the sampling team involved and additional QC samples may be added to the sampling protocol.

Table 8. Use of Quality Control Samples in the Lab

Analysis	Lab Blanks	Lab Duplicates	Spiked Samples	Field Blanks	Field Duplicates
UNH CFB Lab					
Total Phosphorus	B & E	100%	5% or one per analytical batch	10%	10%
Nitrates	B & E	100%	5% or one per analytical batch	10%	10%
E. coli	B & E	10%	NA	10%	10%

* B & E denote the beginning and end of an analytical run.

Table 9. Sample Load Breakdown

Analysis	Total # of Sampling Sites	No. of samples per event per site	No. of events sampled	Field Duplicates	Field Blanks	Total # of Samples to lab
Field Sampling						
Turbidity	10	1	16	1 re-measurement/ sampling location	NA	measured in situ
pH	10	1	16	1 re-measurement/ sampling location	NA	measured in situ
Temperature	10	1	16	1 re-measurement/ sampling location	NA	measured in situ
Dissolved Oxygen	10	1	16	1 re-measurement/ sampling location	NA	measured in situ
Conductivity	10	1	16	1 re-measurement/ sampling location	NA	measured in situ
Stream depth	10	1	16	1 re-measurement/ sampling location	NA	measured in situ
Stream flow	10	1	4	1 re-measurement/ sampling location	NA	measured in situ
UNH Lab						
Total Phosphorus	10	1	16	16	16	192
Nitrates	10	1	16	16	16	192
E. coli	10	1	7	7	7	84

13.0 Instrument/Equipment Testing, Inspection, and Maintenance Requirements

As we will be using NHDES VRAP equipment for the field analyses, prior to bringing any of the equipment into the field, the equipment maintenance log will be checked to ensure the equipment has been properly maintained. If it has not been maintained within the 10 days prior to our sampling visit, the kit will not be used.

The YSI Model 95 Dissolved Oxygen/Temp Meter probe membrane will be inspected for air bubbles prior to field use. All other testing, maintenance, and inspection of the meter will be in accordance with the manufacturer's instructions.

Prior to calibration, the pH electrode will be inspected for dirt and scratches. More filling solution (3 M KCl) will be added if necessary. The conductivity probe will be checked for fouling and scratches. The turbidity meter will be wiped clean and sample cuvettes will be inspected for scratches.

The spectrophotometers used in the analysis of total phosphorus and nitrates at the UNH CFB Laboratory will be inspected and maintained according to the manufacturer specifications. The spectrophotometers will undergo a standard inspection/cleaning at the beginning of the sampling season through the University of New Hampshire Instrumentation Center housed in the University of New Hampshire chemistry department. The standard operating procedures for analysis of total phosphorus, nitrates, and E. coli are included in Appendix C.

The Yellow Springs Instruments SonTek Flowtracker Handheld Acoustic Doppler Velocimeter will be inspected, maintained and tested according to the manufacturer's instructions outlined in the "Flowtracker Operation Manual (March 1, 2002)".

14.0 Instrument Calibration and Frequency

The YSI Model 95 Dissolved Oxygen/Temp Meter will be calibrated prior to each measurement in accordance with the NHDES VRAP Field Calibration and Sampling Protocols (Appendix B5). The calibration for turbidity, pH, and conductivity are included in Appendices B3, B4, and B6, respectively. All calibration records will be recorded on the field data sheet.

At the completion of each batch of analyses, calibration verifications will be performed on the pH, Turbidity, and Conductivity meters. If the calibration checks indicate unacceptable calibration drift (more than 10% difference from calibration value), all samples since the last calibration check will be reanalyzed. The calibration verification standard for the pH, Turbidity, and Conductivity meters will be pH 6.00 solution, 1.0 NTU, and 25 μ S/cm respectively.

The SonTek Flowtracker Handheld ADV does not require calibration.

Before each use the spectrophotometer is inspected and the light path optics of the sample cuvette are cleaned with lens paper. At the beginning of each analytical run, a series of predetermined standards are used to generate a multi-point initial calibration curve. During use, calibration blanks are re-run to check for instrument drift after every ten sample readings and at the end of each sample run. If significant drift occurs (a difference greater than 0.001 Absorbance units), the instrument is recalibrated, blanked and the samples are re-run. Any occurrences are noted in the instrument log.

15.0 Inspection/Acceptance Requirements for Supplies

Sample bottles will be borrowed from the UNH Center for Freshwater Biology. Prior to sampling, the project manager or a designated volunteer monitor will inspect the bottles for breaks or cracks and replace them when appropriate. Sampling teams will take two extra sets of bottles in case of cracks, breaks or contamination discovered in the field. During each sampling visit a total of 14 bottles will be used (Table 10). A 2 L clear bottle will be used to collect both the phosphorus and nitrate

sample. The samples will be poured into the appropriate phosphorus and nitrate bottles at the UNH lab. If samples are also being collected for E. coli analysis, then a total of 36 bottles will be collected.

Deionized (DI) water that will be used for field blanks will be placed in a 2 L polyethylene bottle and transported with other sample bottles to the field.

Table 10. The number of sampling bottles required per sampling event

Parameter	# of Sampling Stations	QA Samples		# of 250 ml Sterile Polyethylene Bottles (E.coli)	# of 2 L clear Bottles (Total Phosphorus & Nitrates)	# of 1 L clear Bottles
		Field Blank	Field Duplicate			
Phosphorus	10	1	1	-----	10	2
Nitrates	10	1	1	-----		2
E. coli	10	1	1	12	-----	-----

16.0 Data Acquisition Requirements

Weather will be monitored through the National Weather Service in Gray, Maine. Active gaging stations operated by USGS in cooperation with the New Hampshire Department of Environmental Services are located at Poor Farm Brook at Ellacoya State Park, Gilford; Lake Winnepesaukee, Weirs Beach; and Shannon Brook, Moultonborough, NH. Gage height, discharge, and precipitation data recorded at these stations will be compared with stream gage and flow measurements made at the monitoring sites.

U.S.G.S. 7.5 minute topographic maps, and aerial photography will be used to delineate the subwatershed of each tributary and to identify land use. Information regarding current and proposed land use activities will be obtained from field visits and the Conservation Commissions of each town in which tributaries are located.

17.0 Data Management

Field data forms will be reviewed and signed by each sampling team before delivering water samples to the UNH Center for Freshwater Biology Laboratory. Upon arrival at the UNH CFB Laboratory the Lab Manager will review the datasheets. The project manager will be contacted within 72 hours if there are unresolvable errors or omissions on the field data forms.

A chain of custody sheet specific to the project will be delivered with the samples to the University's CFB laboratory. The volunteer monitors will log the samples on this sheet and when samples are delivered to UNH/picked up by staff both the person relinquishing the samples and the person receiving the samples will sign off on the sheet accordingly, noting the date and time of delivery/transfer.

The lab manager will review all lab notebooks after QC checks have been completed and determine whether the data are acceptable (if the DQO are not reached the samples will be rerun). The date of completion of laboratory analysis for phosphorus, nitrates, and E. coli will be noted in the sample log book.

The master database will be maintained in an MS-Access Database file. Data entry will be done in a separate excel spreadsheet and reviewed by the Project Manager before being appended to the master database spreadsheet (Figure 3).

After the entry of each sampling event the data will be assessed using summary statistics, mean, median, standard deviation and coefficient of variation to identify potential outliers and possible measurement errors.

Questionable data will be flagged with a code identifying the concern. See **Data Validation and Verification** for details of data quality flag codes.

Figure 3. Example of Spreadsheet Data Base

	Flow Code*	Sample	Sample		pH	Dissolved Oxygen (mg/L)	DO	Cond.	Cond.	Turbidity	Turb.	Phosphorus	Total P	Nitrates	Nitrates
Site	(E/B)	Date	Time	pH	Flag		Flag	(uS/cm)	Flag	(NTU)	Flag	(ug/L)	Flag	(ug/L)	Flag

Flow Code - E = episode, B = base flow

18.0 Assessment and Response Actions

Review of volunteer field activities is the responsibility of the Project Manager in conjunction with the Project QA Officer. A checklist will be used that lists each step of the water sampling and sample analysis process. Volunteer sampling teams will be accompanied and performance evaluated by one of these individuals during two sampling dates. Whenever possible, any required adjustments in sampling technique will occur on-site during the evaluation.

Results of laboratory and field assessments based on QC samples (blanks, duplicates, and spiked samples) will be summarized monthly starting with April 2004. Results will be distributed to the Project QA officer and volunteers. Corrective action will be taken to resolve any problems/issues identified by examination of the QC data. The implementation of any corrective action will be taken only after consultation with the Project QA Officer and will be documented in the project QC report.

State and EPA Quality Assurance officers as requested may review all field and laboratory activities. The QA Officer will perform systems and data quality audits. Any identified procedural problems will be corrected based on recommendations from the QA Officer.

An annual review of the QAPP will be done by the Lake Winnepesaukee Association; any revisions made to the QAPP will be documented in a letter outlining the revisions. If the revisions are minor and do not affect data quality, then the letter will suffice. If the revisions require re-approval of the QAPP, then the revisions will either be documented in a letter or in a revised QAPP that will be submitted for review and re-approval.

Written reports of all evaluations will be kept. The QA evaluations will be submitted with the final report.

19.0 Reports

Results of lab and field assessments will be summarized monthly and reviewed by the project team. In addition, a semi-annual progress report will be sent to NH DES as required in the grant agreement.

The final products of the project will be: 1) QC report assessing data quality using QC samples and internal assessments, 2) the final project report that will include data results, data interpretation, sampling observations. Specific components of the final report will address:

Identification of subwatershed areas that might require further monitoring, planning and/or remedial action as result of this project.

Depending on the data collected/seasonal rainfall patterns - possibly address seasonal variations in water quality, relationships between storm intensity and nutrient (pollutant) loading, identify high priority (problematic) regions.

Summarize and evaluate relative risks to Lake Winnepesaukee from its tributaries

Completion of the final reports is the responsibility of the Project QA Officer.

The QC report and the final project report will be distributed to:

- 1) Pat Tarpey, Lake Winnepesaukee Association
- 2) Rick DeMark, Lake Winnepesaukee Association
- 3) Jeff Schloss, UNH Center for Freshwater Biology
- 4) Bob Craycraft, UNH Center for Freshwater Biology
- 5) Eric Williams, New Hampshire Department of Environmental Services
- 6) Program QA Coordinator, New Hampshire Department of Environmental Services
- 7) Warren Howard, Project Manager, US Environmental Protection Agency (USEPA)
- 8) Conservation commissions in the Winnepesaukee Watershed
- 9) Planning Boards in the Winnepesaukee Watershed
- 10) Belknap County Conservation District
- 11) Carroll County Conservation District

20.0 Data Review, Validation, and Verification Requirements

All field and laboratory data will be reviewed by the Project Manager, Project QA Officer and the Data Manager to determine if the data meets QAPP objectives. The acceptance or rejection of data will be made by the Project Manager in consultation with the QA Officer.

21.0 Validation and Verification Methods

Data entry will be checked by comparison with field data sheets, laboratory notebook data, and reporting forms from the UNH Center for Freshwater Biology. Standard analytical methods will be monitored, and samples will be checked for the required preservation and acceptable holding times by the UNH Center for Freshwater Biology lab.

Data verification will include examining quality assurance data by means of range checks, internal consistency checks of spiked samples and duplicate samples.

Flagging Codes

Questionable data will be flagged with a code that identifies the nature of the concern. The first digit of the flag code will be: F - field or L - laboratory. Laboratory flags will be coded with a second digit to indicate one of the following:

- 1 - QC blank samples were more than 5% different than expected value for the entire batch of samples. All samples in the batch will be flagged.
- 2 - QC spiked samples were more than 5% different than the expected value for the entire batch of samples. All samples in the batch will be flagged.
- 3 - The sample value is more than 2 times the standard deviation of the batch.
- 4 - The sample value is unacceptably high or low and this data should not be used.

Validation involves assessing the reasonableness of the data based on measured and expected values.

22.0 Reconciliation with Data Quality Objectives

Upon completion of each sampling event and receipt of water chemistry results from the UNH lab, determinations for precision, accuracy, and completeness will be made by the Project Manager. If necessary, corrective actions will be implemented. If data quality indicators do not meet the project's specifications, data may be discarded. The cause of failure will be evaluated. If the cause is found to be equipment failure, calibration and/or maintenance, techniques will be assessed and corrected. If the problem is found to be sampling error, sampling methods will be reviewed with all volunteers and retraining will occur when necessary. If completeness, representativeness, and comparability goals are not met, then a resampling visit will be scheduled if time permits and if within project scope and budget. Any limitations on the data use will be detailed in the final project report.

Any revisions in sampling methodology, sample processing, or analytical methods will be submitted to the State and EPA quality assurance officers for approval.

23.0 References

EPA. The Volunteer Monitor's Guide to Quality Assurance Project Plans, Sept. 1996

UNH Center for Freshwater Biology. 2003 Standard Operating Procedures

NHDES Volunteer River Assessment Program. 2003 Water Quality Monitoring Field Sampling Protocols

Henniker Conservation Commission, French Pond Association. 2001. French Pond Episode Assessment Project, Quality Assurance Project Plan.

USGS. Basic Requirements for Collecting, Documenting, and Reporting Precipitation and Stormwater-Flow Measurements. <http://ma.water.usgs.gov/FHWA/products/ofr99-255.pdf>